

CHILDREN'S ABILITY TO PREDICT AND EXPLAIN THE
REASONING OF A YOUNGER CHILD

By

JENNIFER LYN SLAWINSKI

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To my parents, Stanley and Suzanne Slawinski

Dziękuję.

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Jennifer Lyn Slawinski

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Chair: Shari Ellis

Cochair: Patricia H. Miller

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Children's ability to understand the mental states of themselves and others has emerged as one of the most active areas of research in developmental psychology. This research, known as theory of mind, was extended to examine how well children understand a developmental misconception commonly held by other children. Kindergartners and first graders were asked to predict and explain the reasoning of another child who applied this misconception on a problem-solving task. In addition to this misconception-based task, a preference task was used to control for children's ability to draw inferences based on behavioral evidence and to use those inferences to make predictions. Children watched a videotape of a child performing both tasks across multiple trials. In both grades, children were quite skillful at predicting and explaining the child's performance on a preference-based control task. Both kindergartners and first graders were comparably less successful at predicting and explaining the child's misconception. Though participants themselves had overcome the misconception held by the target child, they had difficulty recognizing the target's erroneous reasoning. They

were able to predict the errors made by the target child on only about half of the trials and could explain their correct predictions in terms of the specific misconception only 8% of the time. However, more than half of the children were able to generate the misconception at least once as a post-hoc explanation. Previous research has shown that 5- to 8-year-old children understand that others may hold false beliefs about arbitrary and momentary states of reality. The findings of the present study, however, reveal that children are less successful when asked to predict and explain reasoning based on a fundamental misconception of the world. The implications of these findings for peer learning are discussed.

INTRODUCTION

Research in the area of theory of mind has focused on what it is that people know about the mental worlds of those around them. From its onset, research on theory of mind has been grounded in the assumption that as adults, we operate from a mentalistic or folk psychology concerning others' mental states. As socially skilled beings, we use this folk psychology to predict and explain the actions of others by considering their thoughts and mental activities (Astington, 1993; Astington & Gopnik, 1991). In turn, we negotiate our interactions with others based on our understanding of how people think.

Recent work has demonstrated that even very young children use their nascent understanding of the mental world when interacting with others (Meltzoff, 1995; O'Neill, 1996; Slomkowski & Dunn, 1996). Meltzoff's (1995) findings suggest that children as young as 18 months understand that the actions of others may be based on goals and intentions. These toddlers were successful at reenacting the actions of an adult, even when the adult had tried but failed to perform some act. Meltzoff asserts that the young children did not simply imitate physical movements but were able to make judgments about what the adult wanted to accomplish.

In addition to the evidence that children recognize others' intentions, further evidence (O'Neill, 1996) suggests that young children's communication is based on an understanding of the knowledge state of another. Two-year-olds witnessed toys being placed out of reach while their parents either watched, closed their eyes, or left the room. Children were then prompted to request help from their parents in retrieving the toys. On the trials in which the parents either closed their eyes or left the room, children were more likely to tell them where the toy was or to gesture to its location. Such findings

imply that even quite young children are able to assess what another person knows and use that information to adjust their communication with others. In another look at children's communication, Slomkowski and Dunn (1996) found that skills at recognizing others' thoughts and feelings are associated with effective conversational turn-taking with friends at age 3.

At the other end of the lifespan, studies of adults' theory of mind suggest that healthy older adults maintain high levels of performance on tasks involving theory of mind skills even as performance on other cognitive tasks diminishes (Happé, Winner, & Brownell, 1998). After hearing stories about people lying and making mistakes, older adults were very successful at inferring what the characters in the story were intending and thinking. Adults' performances on these theory of mind stories were better than their responses to questions about information that was presented in control stories.

From results such as these, it seems clear that our communication and interactions with others are shaped by how well we can recognize other people's knowledge, feelings, and intentions. Moreover, such abilities are important across the lifespan and seem to be evident even in the early years of a child's life. What exactly are these theory of mind abilities? And at what age do children exhibit a clear understanding of the mind?

Young Children's Theory of Mind Accomplishments

Most of the research on theory of mind has focused on preschool children and the development of an understanding of minds as entities which involve such concepts as intentions, beliefs, and desires (see Astington, 1993, and Flavell & Miller, 1998, for reviews). The general conclusion to be drawn from theory of mind work is that impressive cognitive achievements are made through the preschool years. For example, 3-year-olds have difficulty attributing inaccurate representations of the world to people. By age 4 or 5, children grasp the idea that what they know to be true may not be known by everyone. Moreover, older preschoolers understand that the mind exists separate from the world, that it maintains connections to the world, and that the representations it forms

about reality are not always correct (Astington, 1993; Flavell, Green, & Flavell, 1990; Flavell, Miller, & Miller, 1993).

These age-related changes in understanding mental representations are based on studies of children's knowledge of false beliefs--the idea that someone can hold an untrue representation of reality (Astington, 1993; Flavell & Miller, 1998; Wimmer & Perner, 1983). False beliefs have been assessed across tasks such as the unexpected locations task (Wimmer & Perner, 1983) and the false contents task (Gopnik & Astington, 1988). In the unexpected locations task, children are presented with a story about conflicting representations of reality. For example, they are told that someone puts an item in one place. This item is subsequently moved by a different person to a new location, and the first person is not informed of this new location. For example:

One day Mark buys some candy at the store. When he gets home, he puts the candy in the cupboard and goes out to play. While Mark is outside, his mom finds the candy and moves it to the refrigerator so that it won't melt. Mark didn't see his mom move the candy because he was outside. After a little while, Mark comes inside to have some candy. He remembers where he put the candy.

Children are first asked several memory prompts to ensure accurate recall of story facts. They are then asked where the first person (e.g., Mark) will look for the candy. Younger children, who do not understand false beliefs, tend to attribute the knowledge of the new location to the first person. They predict that he will look for the item in the new location, even though he did not witness the item being moved. Despite providing accurate responses to the memory prompts, younger children fail to recognize that someone will look for an item in the wrong location even though that is what the person believes to be true.

Similarly, false contents tasks require children to coordinate information about a person's knowledge and their own knowledge of reality (Gopnik & Astington, 1988). Children are shown a container, such as a crayon box, which holds unexpected contents, such as candles. They are then asked to predict what another person (who has not seen

the contents) will think is in the container. Children younger than 4 years tend to incorrectly attribute knowledge of the contents to a naïve person. It is not until the later preschool years that children realize that reality and someone's mental representation of reality do not always match. With the development of this ability, a child can comprehend that someone thinks a box holds crayons when the child herself knows that there are candles in the box. Based on young children's performances on these false locations and contents tasks, researchers have concluded that between the ages of 3 and 5, children develop quite remarkable abilities to discern potential differences between reality and representations of reality.

Even more impressive is how children, by the age of 5, begin to recognize the variety of sources for one's representations of reality (O'Neill, Astington, & Flavell, 1992). For example, children know that sensory experiences lead to knowledge (Pillow & Weed, 1997). Pillow and Weed (1997) demonstrated that, by the age of 4, children correctly identified that only a person who looked in a container would know what was in it; while children younger than 4 believed that a person who had not looked in a container would nonetheless be aware of its contents.

In addition, other findings show that children also appreciate imagination as a source of false beliefs (e.g., Harris & Kavanaugh, 1993; Lillard, 1993; Woolley, 1995). Woolley (1995) gave 3- and 4-year-olds standard false contents tasks and others based on another's imagination of what might be in a container. Children were better able to infer that another would hold a false belief when it was based on that person's imagination.

Studies also show that children can appreciate the effects of holding false beliefs, as in deceptive acts. Hala, Chandler, and Fritz (1991) demonstrated that both 3- and 4-year-olds were capable of tricking a person who was searching for a hidden object. When prompted to deceive an experimenter, children could produce false cues to divert her from the correct location of the object. Some critics argue, however, that while 3-year-olds can manipulate reality in order to deceive someone, it remains unclear whether

they fully appreciate that they are in fact manipulating the person's mental states and beliefs (Sodian, 1994).

Young children's developing knowledge of false beliefs, their sources, and their effects illustrate an improved understanding that people often hold multiple and conflicting representations of reality (Flavell, 1988; Welch-Ross, Diecidue, & Miller, 1997). For instance, in the example of the unexpected locations task, Mark holds one representation of reality (the candy is in the cupboard). Children who hear the story have a different representation of reality; they know the candy is in the refrigerator. Older children who correctly answer the false belief questions about the story recognize the different representations people have about an event or object and can reconcile the conflicts between those representations. They can also appreciate that they themselves have held contradictory representations of reality at different points in time (Taylor, Esbensen, & Bennett, 1994). Children's ability to coordinate various representations of the same event underscores their budding theory of mind.

The idea of conflicting multiple representations is further illustrated in studies that examine the relative ease of understanding different types of false beliefs, such as those based on values or likes (Flavell, Flavell, Green, & Moses, 1990), morals (Flavell, Mumme, Green, & Flavell, 1992), and developmental misconceptions (Miller, Holmes, Gitten, & Danbury, 1997). Flavell, Flavell, et al. (1990) showed that 3-year-olds were able to infer an experimenter's likes and dislikes of items (e.g., cookies, juice) from her behaviors (e.g., making a face). Moreover, children understood that their own value-based representations of an item could be in conflict with another person's representation. Children were shown two flowers (an attractive one and a less-than-attractive one) and were asked to select which one was pretty. An experimenter then said that she did not think the one the child picked was pretty (a different and conflicting representation). Children were consistently able to predict which of the flowers the

experimenter would want to take home; in fact, their performance on these predictions was better than on standard fact-based false belief tasks.

Further work by Flavell (Flavell et al., 1992) using value-based and moral-based false belief tasks did not confirm that 3-year-olds can reconcile multiple representations of an event. These younger children were not successful at recognizing that someone else could hold a different moral approach to a situation or a different value of an item. However, 4- and 5-year-olds could pass such tasks.

Additionally, false beliefs based on developmental misconceptions were examined by Miller et al. (1997). Across three studies, preschoolers' performance on standard false beliefs tasks was compared to their performance on false belief questions based on misconceptions children hold about perspective taking, appearance/reality distinctions, the line of sight principle (knowledge that lines of sight must be straight and unobstructed), and biological growth (e.g., that baby rabbits will grow up to be adult rabbits). Young children did not perform any worse on the misconceptions-based false belief tasks than they did on the standard ones. Thus, during the preschool years, children develop an understanding of misrepresentations of reality that extends beyond tasks based on arbitrary facts (e.g., where candy is located) to those based on natural errors in thinking (e.g., believing that lines of sight do not have to be straight). The developments made during the preschool years indicate that children achieve the ability to attribute diverse representations of reality to other people.

Further Developments in Children's Theory of Mind

Scholars have long acknowledged that major achievements of middle childhood include the development of socio-cognitive skills such as perspective-taking (Piaget, 1926), collaboration (Tomasello, Kruger, & Ratner, 1993), recursive thought (Miller, Kessel, & Flavell, 1970), and metacognition (Baker, 1994). The recent interest in the kinds of understandings that emerge during early childhood coupled with the nativist

orientation of theory of mind work has made it difficult, however, to integrate findings concerning early developments with later socio-cognitive achievements.

One line of theory of mind work has employed traditional types of tasks with samples of older children. The findings indicate that older children simply improve their ability to follow a number of propositions about thinking. Perner and Wimmer (1987) demonstrated that by around 6 to 7 years of age, children are better able to follow recursive lines of thought about false beliefs; they can understand thinking such as “Joe thinks that Mary thinks she’s getting a puppy, but I know it’s not true.” This understanding of recursive thinking does not illustrate any fundamental reorganization of children’s theory of mind but rather a change in the amount of complex information they can consider at one time. Beyond age 5, children can expand how much information about thinking they can consider at one time.

Yet, other scholars have argued that understanding the mind must include qualitative changes (e.g., Chandler, 1988; Fabricius & Schwanenflugel, 1994). Indeed, few would claim that the nature of a 5-year-old’s understanding of the mind is qualitatively similar to that of a 45-year-old. As of yet, it is unclear how thinking shifts across that 40 year span—do shifts in thinking occur all at once, in steps, or across domains? The basic understanding of false beliefs does not allow one to reason maturely about all aspects of potential inaccuracies in thinking (Carpendale & Chandler, 1996).

The main argument of Chandler and his colleagues is that as adults we work from an interpretive conception of knowledge. That is, we do not simply understand beliefs to be correct or incorrect. We understand that people can represent the world with a multitude of different yet equally plausible beliefs and thoughts (Carpendale & Chandler, 1996). Given identical information, two people are unlikely to interpret ambiguous situations in exactly the same way. Chandler’s work has demonstrated that young children cannot recognize that minds interpret and construct a variety of realities, but by

age 7 or 8 children develop a better understanding of the variety of representations of the world (Chandler & Lalonde, 1996).

In Chandler and Lalonde's (1996) studies, 5-, 6-, and 7-year-old children were presented with a restricted view of an ambiguous line drawing (called "doodles") from which it would be difficult to determine what a fuller view of the drawing might represent. For example, one drawing depicts two noncontiguous triangles that could be interpreted as the pointy ends of knives or the tops of witches' hats. When presented with these doodles, only the older children were able to generate more than one plausible description of the fuller picture and attribute such descriptions to others. Older children, in this sense, can not only recognize false beliefs but can comprehend that people may hold a variety of beliefs about the same event or object.

In a different manner, Fabricius and Schwanenflugel and their colleagues have pieced together an approach to the development of theory of mind in even older children and adults. Their work has focused primarily on the changes in the organization of mental verbs which are used to describe various cognitive activities, with a special emphasis on memory (Fabricius & Schwanenflugel, 1994; Schwanenflugel, Fabricius, & Alexander, 1994; Schwanenflugel, Henderson, & Fabricius, 1998). By studying specific knowledge domains such as memory, their focus shifts from an examination of what children know about mental states to what they know about mental activities (e.g., remembering, thinking). Their findings show that between the ages of 8 and 10, children reorganize their approach to mental activities as measured by their use of mental verbs (e.g., remember, know, memorize). That is, they begin to organize aspects of memory (e.g., prospective memory and recall memory) in a more adult-like manner. Children develop a complex hierarchy of the similarities and differences among such activities as remembering, forgetting, and using strategies. With age, they come to understand that people do not simply have static beliefs and thoughts that may be true or untrue, but that the mind is often busy in executing ongoing mental activities.

The development of an understanding that the mind is continually active and processing has also been demonstrated recently by Flavell and his colleagues (Flavell, Green, & Flavell, 1993; Flavell, Green, Flavell, & Grossman, 1997). For example, Flavell et al. (1997) asked young children and adults about the use of inner speech or private, self-directed talking. Adults and 6- to 7-year-olds were more likely than 4-year-olds to attribute the use of inner speech to people. These young children did not believe someone could talk to herself in her head while engaged in an activity such as silently reading a story. In addition to being unable to identify inner speech, young children tend not to report an awareness of a flow of ideas or active cognitive processing (Flavell et al., 1993). When asked about what is in a person's mind during various activities, 3- and 4-year-olds assumed that people's minds are empty when they are doing something such as waiting. Although they believed people had thoughts while solving problems or looking at an item, younger children were less likely to ascribe active thinking to people who are not engaged in cognitive tasks. Such results underscore the possibility that though young children can correctly attribute false beliefs, they may not truly understand all the facets of the mental world until the ages of 6 or 7 or even well into middle childhood.

Drawing Inferences and Predicting Others' Behavior

If our social interactions are grounded in our understanding of the mental activities of others and how their minds work, we must develop some abilities to anticipate and even predict the actions of others (Astington, 1993; Gnepp & Chilamkurti, 1988). How and when does such an ability develop? What information do children draw inferences from? How accurately do children predict the actions of others? Moreover, can children attribute different levels of cognitive abilities to others?

Evidence suggests that beginning at a young age, children can accurately use age as a cue to cognitive abilities. Shatz and Gelman (1973) showed that children as young as 4 years old modified their speech to be appropriate for their listener (either adults or younger children). Moreover, these children talked to same-age peers in the same

manner they conversed with adults. Such findings were further demonstrated across instances of spontaneous free-play situations with mothers, peers, babies, and baby dolls (Sachs & Devin, 1976). When talking to either real babies or baby dolls, preschool children used simpler language (e.g., fewer questions, use of endearments) than when speaking to their mothers or peers. Even without explicit feedback from their listener (e.g., baby dolls) children use age as a salient cue about the characteristics of another with whom they are communicating. Such studies indicate that young children have some rudimentary understanding of a link between age and potential for thought processes and behaviors.

Yet, children's naive theory of age may be limited in scope. Young children appear to understand age as important to communication abilities, but do not demonstrate a mature understanding of the link between age and knowledge. For instance, Montgomery (1993) found that 4- to 8-year-olds who could evaluate the information content of a verbal message nonetheless assumed that an infant would be able to understand the message.

Similar conclusions were drawn by Taylor, Cartwright, and Bowden (1991). They found that 4- and 5-year-olds could make distinctions about the general knowledge held by babies, children, and adults. However, 4-year-olds did not always consider age when predicting what knowledge one can discern from certain experiences. They would often assume that even with limited visual access, adults would be able to recognize hidden objects. Taylor et al. found that young children's understanding of knowledge acquisition is not complete; they believe everyone, regardless of age, can interpret events to which they have only restricted access.

Children have been found to use cues other than age to predict behaviors of other people. Droege and Stipek (1993) asked kindergartners, third graders, and sixth graders to select classmates to be on an academic team and to be their playmates. At all grades, their choices for teammates were those children whom they rated as academically

competent. Even some of the kindergartners were able to articulate relevant reasons for their teammate selections. Young children recognized stable dispositions in people (e.g., likeableness, academic ability) and drew inferences from knowledge of such dispositions. In turn, these children made predictions for future behavior (on an academic team) from these inferences.

Other studies have also shown that young children may be quite capable of predicting what another person will do in the future. Heyman and Gelman (1998) found that even 5- and 6-year-olds were able to use information about people's traits to predict future behavior across different social contexts. Dozier (1991) demonstrated children's ability to predict future generosity in quantitative terms after hearing about an individual's past actions of generosity (or stinginess). Young children even use attributes such as intelligence, traits, and motive to make assumptions about future actions of others, including behaviors in social interactions (Cain, Heyman, & Walker, 1997).

In addition to such attributes as age and dispositions, children may be sensitive to the idea that people can hold biases about others' behavior and thoughts. Pillow and Weed (1995) provided preschoolers, kindergartners, and second graders with information about an observer's bias about another person (e.g., whether or not he liked him). The children were then asked to infer how the observer would interpret the actions of the other person (e.g., would they assume that an action was an accident or was done intentionally). Younger children tended to perform at chance levels; the kindergartners and second graders were better able to use bias information to accurately assume an observer's interpretation of another's actions.

While such research demonstrates that children can use cues such as another's age, preferences, dispositions, and biases to make predictions about abilities and behavior, the question remains whether children can draw inferences regarding cognitive activities. At what age can children recognize the reasoning of another?

In a study of number conservation, Siegler (1995) presents some compelling evidence that children can accurately recognize another's thinking. One group of 5-year-olds were asked to explain an experimenter's reasoning after she had told them the correct answer to conservation problems. In response to the experimenter's question, "How do you think I knew that?," children were able to describe the reasoning that helped her arrive at the right answer. This demand to consider and articulate the thinking of another person promoted better learning and better subsequent performance on conservation problems than just receiving feedback or explaining one's own reasoning did. Siegler argues that children not only can think about another's thoughts, but are at distinct advantage for learning when they engage in this sort of reasoning.

Siegler's demonstration of children's ability to consider someone else's reasoning is relevant to theory of mind work in two important ways. First, the children who could explain how the experimenter solved the problems demonstrated some ability to hold multiple representations about a particular domain or problem-solving task. (Moreover, these children were able to articulate some of their own multiple approaches to the conservation problems.) Thus, children can generalize what they know about conflicting representations of reality to representations within particular domains. Secondly, children demonstrated that they can discern another's representations from behaviors rather than verbal descriptions of thoughts. (For example, in the study by Flavell, Flavell, et al., 1990, children heard the experimenter say that she did not think the flower was pretty.) Although the experimenter in the conservation study described her behavior (e.g., she did not add or subtract any items), she did not explicitly tell the children what she was thinking.

However, in Siegler's study children were asked to consider mature reasoning--that of the knowledgeable experimenter. Children were asked to think about someone who knew the correct answers to the problems. Can children reason about another's thinking when it does not promote the correct answer, when it is based on a

misconception? Furthermore, if they can understand another's reasoning, can they successfully use it to predict another's behavior?

Ellis and Johns' (1997) study of number conservation demonstrated that children seemed to do comparably well at explaining the less mature reasoning of another, but the children were less competent at predicting another's reasoning. They asked children who passed number conservation problems to watch a video of a nonconservor solving the same conservation problems. Nearly all of the conservers could generate an accurate post-hoc account of the nonconservor's reasoning on the problems. However, less than half of the conservers could use the information about the nonconservor's performance to successfully predict what the nonconservor would do on the subsequent trials. Furthermore, all of these conservers were successful at first-order standard theory of mind tasks (false beliefs) and 75% of them could answer second-order theory of mind tasks (recursive thinking). So, although children demonstrated an ability to understand the mental states of others (as measured by theory of mind tasks), they were much less successful at using those skills to interpret and predict the actions of a peer engaged in a cognitive task.

Limitations of Theory of Mind Work

Some clear developments are illustrated in the work on children's understanding of the mind. By the time children enter elementary school, they recognize that people hold mental representations of reality which can be true or untrue. This understanding of representations can be seen across different types of tasks, and some of these tasks may be easy for even younger children. They can also recognize many of the experiences or lack of experiences (e.g., looking into a container, not witnessing an event) that people use to acquire knowledge. They can understand that beliefs and representations are largely based on this knowledge about a particular event or situation. Within the first few years of school, children develop the ability to follow recursive thinking and linked representations. At these older ages, children also become more aware of the various

interpretations different people construct about situations, and learn more about the mind as a continually active processor. As children develop this understanding of the mind, they also become increasingly able to pick up cues to infer what other people may do in different situations.

Despite this broad knowledge we have about young children's capacity to appreciate the mental world, the tasks used in these studies have some methodological limitations. Most of the tasks in the false contents or locations paradigm involve ambiguous and momentary states of reality (Miller et al., 1997). Children's skills are assessed on truths that are present only for the duration of the experiment. Moreover, the mental representations that children are asked about are often those of hypothetical or imaginary people or characters (Chandler & Lalonde, 1996). Thus, children's knowledge of the mind has been studied using the beliefs of fictitious people based on unusual situations. Additionally, children are often given explicit information about what other people think or know. Children are rarely asked to infer others' thoughts simply from their behaviors or actions. While studies have demonstrated that children can infer dispositions of others from behavior, there is little research on whether children can do the same with people's thoughts.

Thus, the current manner in which theory of mind has been examined may be very disconnected from how theory of mind works in real life. In our everyday interactions, we rarely need to consider the thoughts of hypothetical others who explicitly tell us what they know about arbitrary facts. If research is going to demonstrate that people operate from a folk psychology, studies need to provide a better analog to real-life social situations. How well can children explain the reasoning of another child? Can children infer the thinking of a real live child from his behaviors on a variety of tasks?

It is clear that one ultimate goal of theory of mind research is to link children's knowledge of the mind to their social interactions. In fact, a few correlational studies have been done to explore the relationships between understanding the mind and social

skills (e.g., Lalonde & Chandler, 1995; Slomkowski & Dunn, 1996). However, more studies are needed to bridge the gap between examining knowledge of the mind and how this knowledge may be applied in real world contexts. For example, research could better inform us about children's interactions with peers who have conflicting deeply-held beliefs about reality. How are collaborative efforts with peers shaped by what children understand about each other's approaches to the task at hand?

The Present Study

The present study was designed to address two of the limitations of traditional theory of mind research discussed in the previous section. First, children's understanding of false belief was assessed on a task that involved knowledge of physical laws rather than arbitrary and momentary states of reality. Second, a videotape of a real child was used rather than stories of hypothetical characters.

A central question for this research was whether children can hold multiple representations based on misconceptions of others. Therefore, children were required to reason about another child's false beliefs about directions of movement as a result of the physical law of gravity. Understanding of scientific phenomena and misconceptions about such concepts as gravity tend to follow a natural developmental progression (Hood, 1995; Kaiser, Proffitt, & McCloskey, 1985). Studies of children's and adults' understanding of gravity underscore the notion that natural misconceptions do occur in this domain of thinking (Kaiser, McCloskey, & Proffitt, 1986; Kaiser et al., 1985; McCloskey, Washburn, & Felch, 1983). Thinking about others' misconceptions requires holding multiple representations, as in traditional theory of mind tasks; it remains to be seen whether children can accurately represent their own reasoning and another's flawed reasoning or if it is a more challenging task.

Beyond the studies by McCloskey and his colleagues, one set of developmental studies has closely examined the nature of younger children's misconceptions about gravity. Hood (1995) examined children's ability to find a ball dropped into one of three

flexible tubes. Some of the tubes were bent so that when the ball would fall through them, it would land in a cup which was not directly below the top of the tube. Despite the curvature of the tubes, 3-year-olds searched for the ball directly below where it was dropped. Hood described this error as the “gravity” rule; children tended to expect something to fall straight down, regardless of the path it was on. Some changes in procedure (illogical configurations and transparent tubes) led to better performances, but children often failed to generalize their correct understanding on these problems. Some of the older children in his studies were able to overcome this straight-down misconception with repeated experiences with different problems. Based on Hood’s work, it seems clear that young children hold misconceptions about dropped objects and their trajectories. Using Hood’s (1995) study as evidence of a naturally occurring scientific misconception, a task about falling objects was developed to examine children’s reasoning about others’ knowledge and cognition.

The second deviation from theory of mind work was to require children to think about the knowledge of a real child rather than a hypothetical character or puppet. Certainly, the use of a videotape of a real child’s performance is a closer analog to real interactions. Children were not required to understand detailed stories, but could simply watch the behavior of the child. They could then draw information about the other child’s reasoning directly from his behavior. Drawing such inferences from behaviors of those around us is how we often learn about other people. Others rarely provide us descriptions of what they are doing; rather, we attend to their actions for information. This videotape procedure also allowed for presentation of multiple instances of a child’s behavior. Thus, children had repeated opportunities to draw inferences from what the child was doing.

This project consisted of two studies. The first study extended Hood’s work in examining the gravity problems and errors children make. In the second study, children’s ability to predict another child’s reasoning on this problem-solving task was examined.

The goal for Study 1 was to extend and replicate Hood's (1995) findings that young children believe that objects fall straight down regardless of their movement through constrained paths. Hood's procedure was adapted for presentation on a computer. This presentation allowed for more problems of a wider variety and for testing whether children hold any other misconceptions about the task.

The purpose and scope of Study 2 was to broaden what is known about children's ability to reason about the preferences, the thinking, and the misconceptions of another child. Kindergartners and first graders who had overcome gravity misconceptions watched a video of another child performing two computer tasks--the gravity problems and a picture preference task. They were asked to predict and explain the reasoning of the child on both tasks. If children could draw inferences on the basis of behavioral evidence, they would be able to predict the child's behavior. However, children's explanations across the two tasks may vary due to their ability to articulate what they know about the child's reasoning. The question addressed was whether children, when given a limited amount of experience with an unfamiliar child, could reason about the child's developmental misconception and use that information to guess about the child's future behavior.

STUDY 1

Hood (1995) demonstrated that 3- and 4-year-olds tend to predict that things fall straight down regardless of the trajectory of the tube they are falling through. Hood also suggested that young children develop exceptions to this “gravity rule” when perceptual cues (e.g., color) make the trajectory of the tube obvious. The purpose of the present study was to determine whether preschoolers do, in fact, systematically make the gravity error described by Hood and whether their performance varies as features of the problems change.

Method

Participants

Twenty-five children (13 younger preschoolers and 12 older preschoolers) were recruited from a local private elementary school. One of the females in the younger preschool class was not included in the analysis because she did not complete all 23 problems. The remaining 12 participants from the younger preschool class included 9 males and 3 females and were an average of 52.8 months old ($SD = 3.2$). Younger preschool participants’ ages ranged from 47 months to 58 months. The 12 older preschool participants included 8 males and 4 females and were an average of 63.2 months ($SD = 2.6$). Participants from the older preschool class ranged in age from 60 months to 67 months.

Materials

A computer program (“SuperTubes”) was created for use on a Macintosh computer system. This program allows for an interactive presentation of eight different types of gravity problems. These problem types differ in terms of the number of tubes (either two or three), the colors of the tubes (all the same or all different colors), and the

configuration of the tubes (curved or straight). For each problem there is a display of flexible tubes running from the top to the bottom of the screen. Three cups are situated at the bottom of the computer screen. The tops of the tubes are along the top of the computer screen and the bottom of each tube leads to one of the cups at the bottom. In each trial, a ball is dropped into one tube and falls into the cup at the end of the tube. The cups are flush with the bottom of the tube, so it is not possible to see the ball actually land in the cup. Sound effects accompany the animation of the ball dropping and landing in a cup. Twenty-three problems were randomly presented to each participant. Participants' cup choice was recorded for each problem.

In order to assess children's responses, eight problem types were designed. The problem types differed across certain features: the number of tubes, whether the tubes were the same or different colors, whether there was a straight tube in the configuration, and whether the ball was dropped into a straight or curved tube. Features of each problem type are listed in Table 1. The basic tube and cup configurations of the problem types are depicted in Figure 1.

All children were expected to correctly solve problems in which the ball was dropped into a straight tube (problem types V and VII). Thus, children who consistently made the gravity error were expected to respond correctly on 6 problems and incorrectly on 15 problems (types I, II, IV, VI, and VIII). Based on Hood's findings, children were also expected to solve problems that consisted of illogical configurations of tubes (i.e., problem type III). Problem types II and VIII were designed to determine whether any children had a bias to correctly solve problems based on the colors of the tubes.

Procedure

Each participant was tested in a single session in his or her own school. After a brief warm-up period, the experimenter described the computer "game" to the child and showed a Macintosh laptop computer to the child. She explained how the game worked;

Table 1.
Features of the eight types of gravity problems

<u>Type</u>	<u>Number of tubes</u>	<u>Color of tubes</u>	<u>Straight tube?</u>	<u>Ball drops into</u>
I	3	same	no	curved tube
II	3	different	no	curved tube
III	2	same	no	curved tube
IV	2	same	no	curved tube
V	3	same	yes	straight tube
VI	3	same	yes	curved tube
VII	3	different	yes	straight tube
VIII	3	different	yes	curved tube

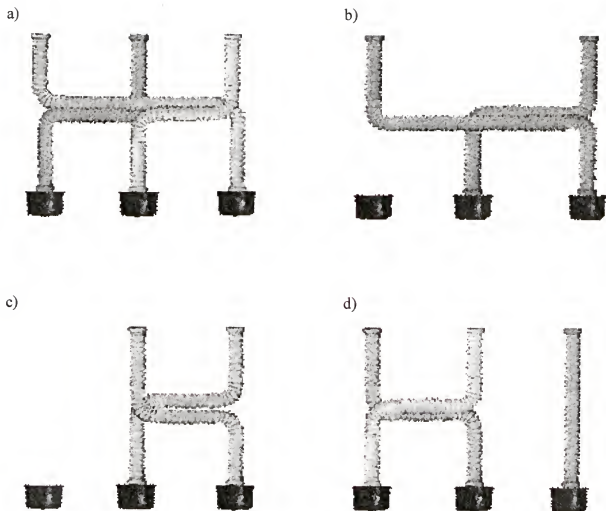


Figure 1. Tube configurations by problem type.

a) Problem types I and II; b) Problem type III; c) Problem type IV; d) Problem types V – VIII

she told the child that the object of the game is to pick where the ball will land after it drops through the tube.

Each child was first shown a practice screen which displayed three icons: a cup (into which the balls would fall on later trials), a troll, and an arrow. Children were allowed to practice using the mouse to click on the icons. The game began once the participant demonstrated that he or she could use the mouse effectively. This usually took less than one minute. For each of the 23 trials, the child clicked on the cup which he or she thought the ball would “fall into.” The child clicked on the troll character in order to advance to the next trial. The child did not receive feedback about whether or not his or her selections were correct. At the completion of all 23 trials, the child was thanked, given a sticker for participating, and escorted back to the classroom.

Results

On average, children responded correctly on 16.8 of the 23 problems (range = 7 to 23). Three children (1 younger preschooler and 2 older preschoolers) made no errors. The 21 remaining children made a total of 150 errors across 460 problems. Of these, 92 were consistent with the gravity rule or straight down reasoning.

The proportion of errors consistent with the gravity rule was calculated for each child. One younger preschooler's responses were consistent with the gravity rule on 19 of the 23 problems (83%). For an additional 5 younger preschoolers, the proportion of their gravity errors exceeded chance performance (as calculated using the binomial test); in fact, for 2 of these children, 100% of their errors were of the gravity type. The errors of 14 children (4 younger preschoolers and 10 older preschoolers) were consistent with chance performance, while one younger preschooler exceeded chance levels of making errors inconsistent with gravity reasoning. The younger preschoolers were more likely to make a number of gravity errors that exceeded chance than were older preschoolers ($p < .05$ as determined by Fisher's exact test); in fact no older preschooler's gravity errors exceeded chance levels.

Errors for the 21 children who made at least one error were further analyzed for whether they occurred randomly across the session and/or across different problem types. The session was divided into quarters and the proportions of errors made in each quarter were compared. A significant difference in proportion of errors across the four quarters of the session was found, $F(3, 60) = 6.81$, $p < .01$. Based on Newman-Keuls pairwise comparisons, the proportion of errors on the first six problems ($M = .44$, $SD = .27$) was significantly more than those on the second six problems ($M = .33$, $SD = .34$), those on the third six problems ($M = .21$, $SD = .21$), and those on the last five problems ($M = .26$, $SD = .25$). In addition, the difference in the proportion of errors between the second six problems and third six problems was also significant. These children's responses included many more errors in first part of the session, and their performances improved across the session's quarters. Participants received all the problems in a random order so these errors were not made systematically within any particular problem type. Lastly, children performed no better on problems where the tubes differed in color than on those trials where the tubes were all one color.

Discussion

The gravity error appears to be a prevalent misconception among young children. One child made this error on more than 80% of the problems, while 5 of the remaining children made this error at rates greater than would be expected by chance. Moreover, the better performances tended to be those of the older children. The younger children tended to be the ones making the gravity error, a finding consistent with Hood (1995).

Overall, the results indicate that gravity reasoning (believing things fall straight down regardless of their path) is a developmental misconception. It is this demonstration of an error in reasoning that is the basis of the problem-solving task used in Study 2.

Beyond simply assessing wrong reasoning, this study tested another important issue for the next study. The present study serves to illustrate that the task designed and used by Hood (1995) is applicable beyond three dimensional, physical demonstrations of

gravity. Given the ease with which children played the game and their success with the task, it seems reasonable to conclude that it was an ecologically valid adaptation of Hood's task. Indeed, Hood's apparatus provided children an opportunity not available in the present study: a real demonstration of physical properties. Yet, children seemed willing to accept that the physical limits of reality are just as applicable on a computer screen. After the initial demonstration and introduction to the game, children were unlikely to ascribe magical properties to these balls; they did not believe balls could float upwards or sideways, but merely attributed reasonable real world rules to these flat images on the screen. Thus, the presentation of a scientific-reasoning based task using such computer technology does not misrepresent what children understand.

From this demonstration of a misconception held by young children, a task was designed for Study 2 in which an older sample of children would be asked to explain this misconception about gravity.

STUDY 2

Traditional approaches to studying theory of mind have their limitations. In designing this study, the goal was to overcome these limitations and provide a real life analog to how children may use their knowledge of the mind to determine another child's thinking. Children were asked to infer the thinking of a child whose reasoning was flawed. Such interactions with peers who hold less mature understanding of a task are the basis of many collaborative efforts in such contexts as school (e.g., Tudge, 1992; Wood, Wood, Ainsworth, & O'Malley, 1995). Therefore, the awareness of the mind that a child brings to such interactions might influence how successful the interactions are.

Kindergartners and first graders were presented with a video of another child engaged in two computer tasks. One task was the gravity problems from Study 1 on which the child in the video consistently made the gravity error. The other task was a control task on which the child in the video selected a picture to color. For both tasks, they were asked to predict and explain what the child was doing. The use of two tasks allowed for a comparison of children's abilities to predict another's behavior. The control (picture selection) task was designed to test whether children in the study were able to draw inferences that were not based on misconceptions (i.e., preferences) and to use those inferences to predict future actions. If children could predict behavior on the control task but not the gravity task, it would demonstrate that children's difficulties on the gravity task involve problems with thinking about false beliefs, not problems drawing inferences from behavioral evidence, nor problems in linking actions from one episode to another (i.e., memory demands).

This video presentation of another child's behavior was used to overcome several of the limitations of studying children's theory of mind. First, children were watching a

real child's actions. Previous research has often relied on the presentation of hypothetical stories in conjunction with puppets or dolls to act out the scenarios. Such stories are often quite long and require many memory questions to ensure that the child has followed the facts of the story. The video presented children with an opportunity to draw inferences from behavior rather than verbal details of a scenario. This presentation was used to provide a better analog to how we learn of others' knowledge in social interactions; we usually observe other's actions rather than listen to descriptions of what they are doing or thinking.

Secondly, this type of task allows for multiple presentations of a target's behavior. Standard false beliefs tasks may be administered multiple times, but are often varied across form and content. The video presentation allowed children to watch the target child's behavior across a number of trials. Thus, children may be able to draw conclusions about the target child based on repeated exposure to the child's behavior. It is likely that given one instance of another's behavior, children establish a theory of that person. This theory might be based on the person's age, gender, or just his or her behavior. Yet, if children are given multiple instances of another's behavior, that theory might need to be adapted. That is, children may use repeated behaviors to construct a new theory about a particular person. Using multiple trials allowed an opportunity to examine whether, over time, children change their theory or understanding of another person's reasoning.

For both the gravity task and the control task, children saw multiple trials of the child's behavior on which they were asked to predict what the child would do. In addition, they were asked to explain (1) how the child arrived at the gravity solutions and (2) why he selected particular pictures on the control task. It was expected that children would have few problems predicting children's preferences on the control task, but might experience some difficulty when predicting children's reasoning on the gravity task. As discussed earlier, previous studies have found that children are skilled at discerning the

preferences of others. However, few studies have examined how good children are at predicting another's performance on a cognitive task. The types of explanations children provided were examined in order to discern what children inferred about the target child's reasoning and preferences.

Method

Participants

Fifty elementary school children (25 kindergartners and 25 first graders) were recruited from a different private school than used in Study 1. Each participant was involved in a single testing session lasting approximately 15-20 minutes. Children were given a sticker for their participation.

The number of errors made on a computer pretest was used to determine if each participant's data were to be included in the analyses. The pretest consisted of eight gravity problems in the computer program used in Study 1. One problem of each of the eight problem types was included in the pretest. Criteria for inclusion in the analyses were that a child had to either (1) make one or fewer errors on the eight problems or (2) get the last six problems correct. Using these criteria, 5 children were dropped from subsequent analysis; these children included 4 kindergartners and 1 first grader.

The 45 participants included in the analysis were 21 kindergartners (10 boys and 11 girls) and 24 first graders (13 boys and 11 girls). For the kindergarten sample the mean age was 73.7 months ($SD = 3.9$) with a range of 68 to 82 months. For the first graders, the mean age was 88.1 months ($SD = 4.5$) with a range of 80 to 100 months.

Materials

As in Study 1, a laptop Macintosh computer was used to present the pretest using the computer program "SuperTubes." The pretest consisted of eight gravity problems. One problem of each type was presented in the following order: VIII, IV, VII, II, III, V, I, then VI.

A portable audio-tape recorder was used to record verbal responses. A television and VCR were used to play videos for each participant to watch.

Two videos were made of a young male confederate playing computer games on the same laptop Macintosh computer. One video was of the confederate playing the “SuperTubes” game. This video showed the young boy (“Daniel”) seated in front of the computer. He received the same instructions to the game (by an off-screen experimenter) that each participant received before the pretest; then he solved eight gravity problems, one exemplar of each problem type in the same order as the pretest problems.

For each trial, another image was superimposed in the lower right corner of the video. This image was the video display of what the confederate saw on the computer screen. Thus, the video displayed the confederate’s actions (i.e. moving the computer mouse) along with the coordinated cursor movements on the computer screen. For each trial, the confederate was shown selecting the cup consistent with the most prevalent error -- the straight down or gravity rule (as discussed in Study 1). Therefore, the confederate was shown correctly answering only two problems (type V and VII) in which the ball falls into a straight down tube.

The other videotape was a control task in which the confederate was using a computer coloring program. Again, two video images were superimposed on the screen. In the upper right corner was the video feed of the confederate sitting in front of the computer, moving the computer mouse. The larger portion of the screen displayed the video feed from the computer -- what the confederate was watching on the computer screen and the coordinated cursor movements. The computer screen had four black and white line drawings displayed across it with the accompanying text, “Click on the picture you would like to color.” The pictures depicted in the line drawings were from popular movies and themes: Aladdin, Beauty and the Beast, Bugs Bunny, dinosaurs, the Lion King, Mickey Mouse, Sesame Street, Star Wars, Winnie-the-Pooh.

For each of eight trials, the confederate clicked on one of the line drawings displayed across the computer screen. For each trial, the pictures displayed were a unique set of pictures that had not been seen before. The confederate always chose a picture from the same movie, “The Lion King”; each of the eight Lion King pictures depicted a different character or scene from the movie. Two of the alternative choices on each trial varied across categories (e.g., Star Wars, Bugs Bunny); the fourth alternative was always from “Sesame Street,” but again, a different character or scene was depicted on each trial. Once the confederate clicked on the picture, the choice was highlighted on the computer screen and an arrow pointed to that picture.

Procedure

Each participant was tested in a quiet, private room in his or her own school by two experimenters. The session consisted of three tasks: the pretest consisting of eight gravity problems, a prediction task for the gravity video, and a prediction task for the control (coloring game) video. For each participant, the pretest was presented first followed by the two prediction tasks. The order of the two prediction tasks and videos was counterbalanced across children. Twenty-three children (11 kindergartners and 12 first graders) saw the control (coloring game) video first and 22 children (10 kindergartners and 12 first graders) saw the gravity game video first. Each participant’s responses for the prediction tasks were written down and audio-taped for coding purposes.

Pretest. When the participant was first brought into the room, he or she was directed to the computer. One of the two experimenters described the computer “game” to the child and showed the laptop computer to the child. She explained how the game worked; she told the child that the object of the game was to pick where the ball would land after it dropped through the tube. The child was told that he or she would have to click on the cup in which the ball would land.

Each child was shown a practice screen and given approximately 30 seconds to practice using the mouse and clicking on the appropriate icons on the screen. During this practice, there were no tubes shown on the screen; children only saw a cup, a troll, and an arrow. Once the participant had successfully clicked on the appropriate icons, he or she was allowed to start the game. For each of the eight trials, the child clicked on the cup which he or she thought the ball would “fall into.” At the completion of a trial, the child clicked on the troll character in order to advance to the next trial. No feedback was given to the children about their responses to the gravity problems.

Following the pretest, the participant was told that he or she would now be watching a couple of videos of another child playing similar computer games. The experimenter told the participant that she would be asking him or her some questions about the video and that the other experimenter would be writing down the answers. The participant was also shown the audio-tape player and was told his or her answers would be recorded. The two videos were then shown to the participant.

Control task. As an introduction to the video of the child choosing pictures to color, the experimenter explained that a boy (Daniel) was playing a computer coloring game. The experimenter described the game: that each time Daniel has a choice of four pictures but he has to select only one to color. For each of the eight trials, the video was paused before Daniel made his picture selection and the experimenter asked, “Which picture do you think Daniel will pick to color this time?” The experimenter then pointed to each of the four pictures and named the movie or theme of the picture (i.e., Lion King, Star Wars, etc). When the participant pointed to or named the picture he or she thought Daniel would pick, the experimenter asked, “Why do you think he’s going to pick that one?” After the child explained his or her prediction, the experimenter said “Let’s see which one he does pick” and pushed the play button.

If the participant had predicted Daniel’s choice correctly, the experimenter let the video go on to the next trial. If the participant’s prediction had been incorrect, the video

was again paused. In an attempt to prompt the child to explain Daniel's behavior, the experimenter said, "Well, Daniel picked this one, the Lion King. But you thought he would pick X. Why do you think he picked the Lion King instead of X?"

Gravity task. As in the control task, the experimenter explained that Daniel was playing a computer game – the same game the participant had played at the beginning of the session. The participant then watched a portion of the video in which Daniel received the same game instructions that he or she had received earlier. The experimenter also explained that not all children played the gravity game the same way and that Daniel might or might not pick the same cups that the child him or herself would pick.

For each of the eight trials, the video was paused before Daniel clicked on the cup he selected and the experimenter asked, "Here are the tubes Daniel is looking at. Which cup do you think Daniel will think that the ball will land in? Which cup will he pick?" When the participant pointed to or named the cup he or she thought Daniel would pick, the experimenter asked, "Why do you think he's going to pick that one?" After the child explained his or her prediction, the experimenter said "Let's see where Daniel thinks the ball will land" and pushed the play button.

If the participant had predicted Daniel's choice correctly, the experimenter let the video go onto the next trial. If the participant's prediction had been incorrect, the video was again paused. In an attempt to prompt the child to explain Daniel's behavior, the experimenter pointed to the television screen and said, "Well, Daniel picked this cup. But you thought he would pick this one. Why do you think he picked this one instead of this one?" At the end of the session, each participant was thanked, given a choice of a small sticker, and escorted back to his or her classroom.

Coding

The types of explanations offered by participants are described in Table 2. Twenty percent of the trials on the control task and on the gravity task were randomly

Table 2.
Types of explanations and post-hoc explanations

<u>Explanations and descriptions (both tasks)</u>	<u>Example</u>
No response	
no verbal or nonverbal response offered	
Don't know	
an indication that child does not know	"I don't know"/shrugs
Other - includes:	
1. Self-reference	
reference to own performance	"I would pick it."
2. External Motivation (control task only)	
reference to features of the picture choices	"He needs a Timone picture."
3. Confederate's reasoning (gravity task only)	
describes flawed logic that is not the gravity rule	"He thinks these tubes are connected in the middle."
4. Mentalistic (gravity task only)	
reference to Daniel's mental processing	"He's not paying attention."
5. Perception (gravity task only)	
describes what the tubes look like without attributing it to Daniel's thinking	"It looks like the tubes could be connected here."
Attributes	
1. Age	
describes behavior with regard to Daniel's age	"He's little." "Little kids would pick that one."
2. Gender	
describe behavior in terms of Daniel's gender	"Boys like that picture."

Table 2 continued.

3. Likes	“He really likes Lion King.” “Lion King’s his favorite.”
description in terms to Daniel’s preferences	
4. Cognitive ability	“He’s not smart.” “He’s confused.”
description of Daniel’s ability to think	
5. Wants	“He wanted to pick that one.”
describes what Daniel desires	
Evidence from past behavior	
references what Daniel has done on previous	“He picked it before.”
trials	“He keeps picking that one.”

Explanations and descriptions (for gravity task only)ExampleReality/Own Reasoning

1. describes tube’s path

description of the tube the ball is falling into or

“The tube goes that way.”

the correspondence to the correct cup

“That’s the right cup for that tube.”

2. points to tube

child traces the path of the tube on the screen

Gravity Rule

description of Daniel’s behavior as consistent with

“He thinks it goes down.”

the straight down rule

“He’s gonna pick the cup under the ball.”

selected to assess reliability of the scoring of children's explanations for their predictions and post-hoc explanations. Across both tasks, for both explanations and post-hoc explanations, independent raters' agreement ranged from 88% to 97% for an overall average of 94% agreement.

Six types of explanations were coded for both the control task and the gravity task: no response, don't know, other, attributes, evidence from past behavior, and self-reference. Several types of explanations were specific to the gravity task. For the gravity task, responses were often specific to the path of the tubes, where a ball might roll, or the location of the cups. Children were credited with a gravity rule response if they mentioned that Daniel thought the ball fell straight down, or that they recognized that Daniel was selecting the cup directly below the ball's starting point.

For both the control task and the gravity task each child's explanations on trials 2 through 8 were coded and a proportion of use was calculated for each category. Across all eight trials, children's post-hoc explanations were coded for the trials on which their predictions were wrong.

Results

As discussed in the Participants section, a pretest consisting of eight gravity problems was administered to all the children. Of the 45 children who met the criteria for inclusion in the study, 40 made no errors, 3 made one error, and 2 made two errors on the pretest.

For both the control task and the gravity task, there were three measures of children's understanding of the confederate's behavior: predictions, a priori explanations, and post-hoc explanations. Children's performance on each of these measures for both tasks will be discussed separately.

Predictions

Each task consisted of eight trials for which the participants made predictions about what the confederate (Daniel) would do. For the purposes of analysis, only the last

seven trials were considered as prediction trials. Without any prior experience watching Daniel's behavior, it is unlikely that children could correctly assume which picture Daniel might prefer or whether or not he could correctly solve the gravity problems. Therefore, predictions were only considered after the first trial provided an example of Daniel's performance.

Preliminary analyses of the predictions indicated no effects for gender or order of tasks. Therefore, these variables were removed from the subsequent analyses.

Control task. As expected, all children were quite successful at correctly predicting Daniel's picture selections. On average, children correctly predicted Daniel's picture choice on 86% of the trials ($SD = 14\%$) or on about 6 of the 7 trials. There were no differences across the two grades ($F < 1$); kindergartners predicted correctly on 85% of the trials ($SD = 13\%$) and first graders averaged 87% of the trials ($SD = 15\%$).

For each child, the trial on which his or her predictions were consistently correct (did not make a mistake on any further trials) was also calculated. Scores could range from 2 to 9. A score of 9 was given if a participant was not consistently correct by the final or eighth trial. Only two kindergartners were given a score of 9; no first graders were given a 9. On average, children were consistently correct by the third or fourth trial ($M = 3.4$, $SD = 1.7$). As with the percentage of correct predictions, no grade differences were found ($F < 1$); kindergartners were consistently correct on average by the third trial ($M = 3.1$, $SD = 1.1$) and first graders by the third or fourth trial ($M = 3.6$, $SD = 2.0$).

Gravity task. On average, children correctly predicted Daniel's cup choice on 52% of the trials ($SD = 20\%$) or on about 4 of the 7 trials. There were no differences across the two grades ($F < 1$); kindergartners predicted correctly on 53% of the trials ($SD = 23\%$) and first graders averaged 51% of the trials ($SD = 18\%$).

Unlike the control task, the gravity task trials were not necessarily equal in their difficulty levels because each consisted of a different problem type. Trials 3 and 6 consisted of problem types VII and V, respectively, in which the ball is dropped into the

straight tube. (Refer back to Figure 1 for tube configurations.) Based on the confederate's behavior of always choosing the cup directly below, he got both of these problems correct. Thus, children could predict the correct cup choice for these trials based on their own correct reasoning, even if they could not explain Daniel's reasoning (that things fall straight down). For the other trials and problem types, Daniel's behavior was not consistent with the correct answer; thus these problems were more difficult. Therefore, an analysis was done to examine differences in children's correct predictions across problem types V and VII versus the remaining problem types.

For each participant, the percentage of correct predictions on (1) easier problem types (V and VII, trials 3 and 6) and (2) more difficult problem types (I, II, III, IV, and VI, trials 2, 4, 5, 7, and 8) was calculated separately. A 2 x 2 (grade by problem types) repeated measures ANOVA revealed a significant main effect of problem type, $F(1, 43) = 207.92$, $p < .01$. The percent of correct predictions for the easier problem types (V and VII) averaged 94% ($SD = 22\%$), significantly more than for the more difficult problem types (I, II, III, IV, and VI) ($M = 35\%$, $SD = 25\%$). No main effect of grade was found, $F < 1$. Note that with only two exemplars of easy problems there was a restricted range of possible scores while children's scores on the harder problems were based on five problems.

In addition to the main effect of problem type, a significant interaction between grade and problem type was found, $F(1, 43) = 5.61$, $p < .05$. For the easier problem types, kindergartners averaged 88% ($SD = 31\%$) and first graders averaged 100% ($SD = 0\%$). (Two kindergartners predicted wrong on both trials 3 and 6; one kindergartner got trial 3 wrong. Two of the kindergartners did not provide any explanations for these errors on trial 3, while one child claimed that Daniel "keeps picking that cup." No first graders made any errors in predictions for trials 3 and 6.) For the more difficult problem types, kindergartners averaged 39% correct ($SD = 24\%$) and first graders averaged 32% ($SD = 25\%$). Using Tukey's HSD pairwise comparisons, kindergartners and first

graders' predictions were found to be approximately equal for both the easier problem types (V and VII) and for the more difficult problem types (I, II, III, IV, and VI).

Lastly, as with the control task, each child was given a score based on the trial on which his or her predictions were consistently correct (did not make a mistake on any further trials). Again, scores could range from 2 to 9 and a score of 9 was given if a participant was not consistently correct by the final or eighth trial. Six kindergartners and 8 first graders were given a score of 9. The 31 children who began to make correct predictions were consistently correct by the sixth or seventh trial ($\underline{M} = 6.7$, $\underline{SD} = 1.8$). As with the percentage of correct predictions, no grade differences were found ($\underline{F} < 1$); kindergartners were consistently correct by the same point as the first graders ($\underline{M} = 6.7$, $\underline{SD} = 1.9$, and $\underline{M} = 6.8$, $\underline{SD} = 1.7$, respectively).

Task comparisons. Analyses were conducted to examine differences across the two prediction tasks. First, a 2×2 (grade by task) repeated measures ANOVA was done on the percentage of correct predictions on trials 2 through 8. The only significant effect found was a main effect for task, $\underline{F}(1, 43) = 98.92$, $p < .01$. Children were better able to predict Daniel's choices on the control task ($\underline{M} = 86\%$, $\underline{SD} = 14\%$) than on the gravity task ($\underline{M} = 52\%$, $\underline{SD} = 20\%$).

Next, a 2×2 (grade by task) repeated measures ANOVA was done on the trial on which a child's predictions became consistently correct. This analysis was done for the 14 kindergartners and 16 first graders who were consistently correct in their predictions for both tasks. A significant main effect of task was found, $\underline{F}(1, 28) = 51.16$, $p < .01$. Children's predictions were likely to become consistently correct earlier in the control task ($\underline{M} = 3.3$, $\underline{SD} = 1.8$) than in the gravity task ($\underline{M} = 6.7$, $\underline{SD} = 1.8$). No main effects for grade were found. Based on children's ability to predict the confederate's behavior, the gravity task was considerably more difficult for children of both ages, while the control task was equally easy for both age groups.

Explanations

For each child, the proportions of use for each explanation type were calculated for the control task and the gravity task. Preliminary analyses of the explanations indicated no effects for gender or order of tasks. Therefore, these variables were removed from the subsequent analyses, and only differences across the two grade levels were examined.

Control task. For four of the categories of explanations (don't know, other, attributes, and evidence from past behavior), a MANOVA was done on the proportions of category use by grade to control for Type I errors. The multivariate test for grade differences was not significant, $F(4, 40) = 2.06, p > .10$. However, based on planned comparisons to examine grade differences for each explanation, two univariate tests were significant: for the don't know category, $F(1, 43) = 5.91, p < .05$, and for the evidence category, $F(1, 43) = 4.81, p < .05$. When asked why they predicted a particular picture selection for Daniel, kindergartners said they didn't know why more frequently ($M = .14, SD = .22$) than did first graders ($M = .02, SD = .05$). However, first graders justified their predictions with evidence of what Daniel had done in the past ($M = .60, SD = .43$) more often than did kindergartners ($M = .34, SD = .39$). Children in both grades explained their predictions in terms of various attributes (e.g., age, likes) ($M = .27, SD = .36$) and other ($M = .13, SD = .23$) in comparable proportions. The number of children who used each of the four explanations at least once is displayed in Figure 2. The explanations based on evidence and attributes tended to be those offered by more children.

In addition, the number of different types of explanations used by each child on the control task was calculated. On average, children used 2.11 ($SD = 1.01$) different types of explanations for the control task. There were no grade differences; kindergartners averaged 2.33 ($SD = .86$) and first graders averaged 1.92 ($SD = 1.10$), $F(1, 44) = 1.97, p > .10$.

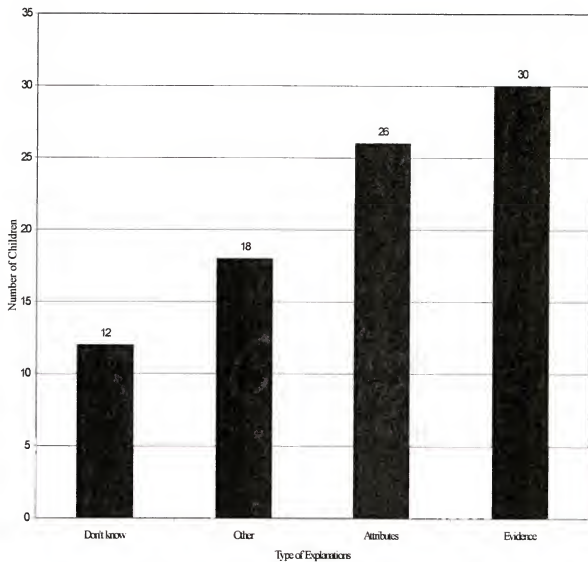


Figure 2. Number of children who offered each type of explanation on the control task

Gravity task. The proportion of use of each type of explanation for the gravity task was examined for each child. To control for Type I errors, a MANOVA was used to examine grade differences in the proportions for reality/own reasoning, gravity rule, evidence, don't know, and other. The multivariate test for grade differences was not significant, $F < 1$. However, as with the control task, planned comparisons were examined for grade differences for each explanation. Only one univariate test was significant, the don't know category, $F(1, 43) = 4.70$, $p < .05$. As in the control task, kindergartners said they didn't know ($M = .14$, $SD = .24$) in significantly higher proportions than first graders ($M = .02$, $SD = .07$). Kindergartners and first graders offered the remaining explanations in approximately equal proportions: other ($M = .09$, $SD = .13$), reality ($M = .64$, $SD = .34$), gravity rule ($M = .08$, $SD = .16$), and evidence ($M = .06$, $SD = .15$). The number of children who used each type of explanation at least once is displayed in Figure 3. The number of children who offered explanations based on reality far exceeded the number of children who offered the four other types of explanations.

Of all the categories of explanations on the gravity task, the gravity rule one was of the most interest. If children could offer this type of explanation, they demonstrated the best description of Daniel's behavior in the videotape. While children might not have offered this gravity rule in support of their predictions, they might have generated it as a post-hoc explanation when their predictions proved wrong. Of the 45 participants, 24 (9 kindergartners and 15 first graders) used an explanation about the gravity error either to support a prediction or as a post-hoc explanation at least once. Of this subset, the gravity reasoning was first used as a post-hoc explanation by 22 children while 2 children generated the gravity reasoning to support a prediction. Of the 22 who provided the gravity rule as a post-hoc justification for Daniel's behavior, 11 of these children did so on the first trial.

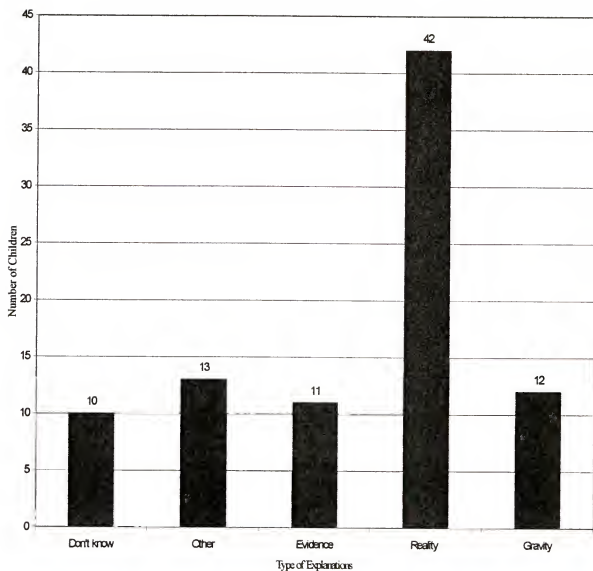


Figure 3. Number of children who offered each type of explanation on the gravity task

In addition, the number of different types of explanations given was calculated. The average number of different explanations on the gravity task was 2.18 ($SD = 0.94$).

Lastly, the number of different types of explanations for both the control task and the gravity task was compared. No differences were found for grade ($F < 1$) or for task ($F < 1$). There were no differences between kindergartners ($M = 2.19$, $SD = 1.08$) and first graders ($M = 2.17$, $SD = 0.82$), $F < 1$. Across both tasks, children averaged somewhere between two and three different explanations for their predictions of Daniel's computer selections.

Final Status on the Gravity Task

The last two trials of the gravity task were examined for whether children could both predict Daniel's behavior and justify these predictions with the gravity rule. Those children who met this criterion would have demonstrated that by the end of the task, they could understand how Daniel was reasoning about the gravity problems. Thirteen children (6 kindergartners and 7 first graders) were able to successfully predict Daniel's behavior on the last two trials. Of these 13 children, 3 kindergartners and 5 first graders justified these predictions with some explanation of the gravity rule. Three kindergartners and 2 first graders were successful at predicting the last two trials but did not offer the gravity rule on both trials. (One kindergartner and one first grader did offer the gravity rule on trial 7 but then offered other types of explanations on trial 8.) These frequencies across the two grades were not significantly different, Fisher's test, $p > .10$.

There were an additional 3 first graders who did not correctly predict Daniel's behavior for trial 7, but successfully predicted his behavior on trial 8 and provided a gravity rule explanation for his behavior.

Discussion

Children's Predictions

The results provided mixed support for the idea that children are capable of inferring another's reasoning on a cognitive task. Both kindergartners and first graders

were able to correctly predict the target child's behavior on only about half of the gravity problems. On trials with more difficult problem types, children often predicted that Daniel would select the correct solution when he was actually wrong. Children's predictions for two trials (3 and 6) were often correct because Daniel's behavior was consistent with the correct answer and, thus, with their own reasoning. Although it took them until the end of the session (trial 6 or 7), 69% of the children were able to consistently predict Daniel's behavior.

The results of the gravity task suggest that 5- to 8-year-olds have difficulty predicting the behavioral consequences of another child's reasoning. Yet, the children's performance on the control task provides a clear demonstration that this is not true. Children were able to correctly predict Daniel's picture preferences on over 80% of the trials. In fact, children were usually consistently correct in making these predictions by the third or fourth trial. One argument for the children's success at predicting Daniel's picture choices could be that his choices were consistent with their own preferences among the pictures displayed; perhaps these children also preferred Lion King pictures to the other choices. However, only 13% of the children offered a correct prediction on the first trial. (With no prior experience with Daniel's choices and four different pictures, it would be expected that 25% of the children would randomly arrive at the correct prediction.) And, fewer than 6% of the children explained that their choice on the first trial was a picture that they themselves liked. Furthermore, children's explanations on subsequent trials indicated that children were making predictions based on Daniel's behavior on the video, not on their own preferences. These explanations will be discussed in detail later.

It is possible that children were inferring Daniel's reasoning on the gravity task, but that these inferences were not consistent with the gravity error. Children may have attributed a different misconception about gravity to him. This was examined further by looking at children's incorrect predictions. For almost all children, predictions of

Daniel's responses to the gravity problems were consistent with correct reasoning about the problems. Only a few (< 8%) children ever offered a prediction that Daniel would select the cup which was neither consistent with the right answer or the gravity error; moreover, these children only did so on one or two trials, not across multiple trials. So, while children's predictions were consistent with the gravity misconception on half of the trials, their predictions on the remaining trials did not correspond to any other plausible misconception that could be generated. Nor, did children explain their predictions in terms of other misconceptions or biases (e.g., He will always pick the middle cup).

Overall it is evident that children were distinctly better at predicting Daniel's future behavior from his past performance on the control task than on the gravity task. Therefore, it seems plausible that children find it less complicated to use past evidence to infer people's preferences than to infer their misconceptions on a cognitive task. The ability to predict preferences is in line with early work that suggests that children can infer the dispositions of others (e.g., Dozier, 1991; Droege & Stipek, 1993). Similarly, the finding that children may have some difficulty with predicting other's performance on a cognitive task is in line with past studies (e.g., Ellis & Johns, 1997).

The children in this study were past the age at which children make mistakes on standard false belief tasks (Gopnik & Astington, 1988; Wimmer & Perner, 1983). Yet, their performances across the two tasks do not seem consistent; more of the children could attribute preferences to Daniel than could attribute a misconception or false belief to him.

Children's Explanations

The tasks used in this study differed somewhat from traditional theory of mind false belief tasks. Children were not only asked to make predictions about Daniel's behavior on multiple trials, but they were required to justify the predictions they offered.

On the control task, children's most prevalent explanations were based on reasoning from past evidence and what attributes they assumed about Daniel. The first

graders offered significantly more justifications based on past evidence (for example, Daniel “picked Lion King pictures before”) than did kindergartners. Despite this difference, it is important to note that many children in both age groups said that they drew inferences directly from Daniel’s behavior on previous trials. Sixty-seven percent of the children were able to offer this explanation based on past behavior on at least one trial, suggesting that children are cognizant, not only of others’ preferences, but of the basis for drawing such inferences.

Another age difference indicated that kindergartners were more likely than first graders to say that they did not know why he might pick the pictures they predicted he would. Yet, they were just as good at making predictions as were the first graders.

Children in both age groups were also able to use these preferences to justify their predictions (for example, “He really likes the Lion King. It’s his favorite.”). Again, children can not only infer what others like, but can describe these preferences in conjunction with predicting a person’s future behavior. Although Daniel never offered a verbal indication of his favorite types of pictures, children tended to assume that his consistent choices indicated something about what he liked and did not like.

Interestingly, while children frequently justified their predictions on the basis of past evidence on the control task, children rarely offered this as an explanation on the gravity task. Children used Daniel’s past behavior as an explanation on fewer than 10% of the trials on the gravity task; however, children offered it to justify predictions on the control task on about 50% of the trials.

Instead, children tended to explain Daniel’s performance on the gravity task in terms of the configuration of the tubes (that is, reality) or their own reasoning. They would explain in detail the path of the tube, the way it curved (or did not curve), and which cup was directly beneath that particular tube. Given that many of their predictions were based on the right answer for the problem, it is not too surprising that children then explained how one would arrive at that correct answer.

What is surprising is that these children did not attribute a false belief or misconception about gravity to Daniel. They were more likely to explain the solution to the problem from their own reasoning rather than consider what it was that Daniel was doing on the problems. Although they were asked to predict which cup Daniel would pick for a particular problem, their responses and justifications were more consistent with their own perfect performance on the pretest. These attributions of their own reasoning to another child are unanticipated among children who are beyond the age when false belief tasks are difficult. First graders and most kindergartners would find false locations or false contents tasks quite easy to understand.

Not all children attributed their own reasoning to Daniel, however. Twenty-nine percent of the children were able to correctly account for Daniel's behavior (and his misconception about the direction of the falling ball) on at least one of the last trials. However, most of these children took until nearly the end of the session to discern Daniel's reasoning. It may be that watching repeated instances of another's behavior was informative for the children. However, it is unclear that more children would have been able to justify Daniel's behavior as the gravity error if even more trials were added. Despite the repeated evidence of Daniel's "straight down" cup choices on the gravity task, most children were still guessing that his future behavior would be consistent with their own.

Accounting for Children's Performance

The foremost finding from this study is the markedly distinct performance by children on predicting Daniel's preferences and his cognitive misconceptions. Children were quite successful at determining the pictures Daniel would select and justifying their predictions. However, not all children showed such success at determining Daniel's solutions to the gravity problems. Fewer of the children could consistently account for Daniel's behavior on the gravity task as a result of a misconception that the ball fell straight down regardless of the tube. The obvious question to answer is why were fewer

children able to conclude what Daniel was doing on the gravity task than were able to do so on the control task?

One plausible account of children's performances is the simple nature of the two tasks used. The gravity problems were a new and engaging task for the children. While they found the problems easy to solve, they may have found the task so novel that they were too busy considering how they themselves solved such problems. This novelty may have prevented children from considering Daniel's perspective as they were focused on their own thinking. Furthermore, children did not experience this same prior exposure to the control task; they were not given an opportunity to play with the picture selection computer game. Had children had experience selecting the pictures themselves, it seems plausible that they may have had some difficulty discerning Daniel's preferences from their own.

This prior exposure to the gravity task makes some sense given the frequent number of explanations children offered about their own reasoning. While children seemed surprised when Daniel got problems wrong, they often approached their prediction for the subsequent trials as if it were independent of previous ones. That is to say, although children were asked to predict Daniel's behavior, they showed little evidence that they either remembered or thought about his prior mistakes. Their remarks were more directed toward the gravity problem at hand rather than Daniel's behavior on the problem. (It is important to note that if children seemed to describe their own solutions to problems, they were prompted with questions such as, "Do you think that's what Daniel will pick?") Nearly all children answered such prompts in the affirmative. Those who didn't were reminded that they needed to offer what Daniel would do.) Children may have been engaged in solving the gravity problems first and predicting Daniel's behavior was a secondary goal for them.

A second explanation of children's different performance on the two tasks may be that children can not provide complete accounts of what other people may be thinking.

Consider that 69% of the children were able to predict Daniel's gravity problem solutions while 29% were able to predict and explain these predictions. Practically all of the children could both predict and explain his picture selections. Why the disparity in the numbers of children?

One explanation may be simply that of limited language abilities. As discussed, kindergartners more often claimed that they did not know how to justify their predictions, even when their predictions were correct. Although younger children can predict behavior of others, they may be at a disadvantage in terms of verbalizing why they know what someone else will do. This may be due to less extensive vocabularies. Yet, these children were older than usual samples in theory of mind studies and were assumed to have better developed language abilities to provide adequate verbal accounts of Daniel's behavior or thinking.

A second, more convincing explanation has to do with the nature of children's understanding. Do these children have an explicit awareness of Daniel's thoughts or simply an implicit understanding of what he is doing? Previous demonstrations that preschoolers understand the mind are largely based on their predictions for the future. To return to the unexpected locations task example, children have "passed" the task when they accurately predict that Mark will look for the candy in its original location. They are not asked to describe what Mark believes to be true, and thus they provide no explicit information about their understanding of his beliefs. Yet, shall we depend on such predictions as evidence that children have a clear understanding of beliefs?

The issue of which criteria to use as evidence of competence is one that reaches across many areas in developmental psychology (see Keil, 1989, and Thomas & Horton, 1997, for examples). Are judgments and predictions adequate markers of complete understanding? Or does requiring a verbal account of what others are doing indicate further developments in understanding? If children can provide a more detailed account of another's beliefs or thoughts, does this indicate a more developed theory of mind?

There is some evidence that explaining another's behavior may be a better test of children's theory of mind (Robinson & Mitchell, 1995). Robinson and Mitchell have found that younger children could provide an adequate explanation for behavior after watching a person's actions. It is certainly credible that some understanding of another's thoughts must be based on that person's actions. (For instance, Flavell, Flavell, et al., 1990, found the young children could distinguish another's likes and dislikes from facial expressions.) Such findings are consistent with the fact that children were able to describe Daniel's misconception on the gravity task after watching his behavior on a particular trial. However, some have argued that it is not until children can understand beliefs that they can provide these backward explanations of events (Moses & Flavell, 1990). As discussed earlier, these children would certainly find standard false belief tasks relatively easy; they understand beliefs, but do not appear to use that understanding to account for Daniel's behavior on the gravity task.

Potential Individual Differences

The tasks used in the present study were designed to tap into what children know about the mind. Children's ability to predict and explain Daniel's behavior on two tasks was largely dependent on several skills. First, children needed to understand the mind and mental representations; it is reasonable to assume they could do this based on their age (Astington, 1993; Flavell, 1988). Secondly, children needed to separate their representations of reality from the representations of others. Again, this is something that can be easily attributed to them. Given that we can assume that these children all came into the study with the rudimentary elements of a theory of mind, a question remains about children's performance on the gravity task. Why weren't all the children coordinating their predictions for Daniel's behavior with an account of his misconception? What could predict the individual differences in performance on the gravity task?

One possible prediction for whether children could adequately explain Daniel's reasoning could be based on whether children generated a post-hoc explanation of the gravity error. Twenty-two children could generate such a backward explanation of his misconception. Yet, not all of these children could then use this plausible explanation to predict Daniel's subsequent behaviors. Over half of them provided this post-hoc explanation and then went back to predicting Daniel would get the subsequent problem correct. Such discrepancies between post-hoc accounts and later predictions of behavior are consistent with other research (Ellis & Johns, 1997). If backward explanations do not discriminate between those who could and those who could not explain Daniel's misconception, what other factors might be at work?

One individual difference in performance on the gravity task might be the nature of children's explanations. The language of theory of mind, or using verbs related to mental states and understanding, may be a possible clue to how children consider the thoughts of others (Astington & Pelletier, 1996; Schwanenflugel, Henderson, & Fabricius, 1998). Children's explanations were scrutinized for whether they described Daniel's behavior by referring to his mental states. Such explanations fell under the "Other" explanations and were labeled as "Mentalistic" and "Perception" types of explanations. These explanations were comprised of children's mentions of mental processing (e.g., links between knowledge and attention) and sensory experiences and knowledge (e.g., what the problems looked like and led one to believe). If children are aware that this task demands that they consider the thoughts of another person, their discussion of those thoughts may reflect this awareness. Interestingly though, only 6 out of the 45 children ever offered either of these types of explanations. In fact, these explanations constituted less than 4% of all the explanations offered by children. So, although these children could likely pass standard false beliefs tasks and some recursive thinking tasks, few of them spontaneously use the "language" of theory of mind to explain Daniel's thinking. That is, children were not likely to describe what Daniel was

doing in terms of mental states or knowledge based on perceptual access. Furthermore these few children did not do any better on the gravity task than other children.

This apparent lack of “theory of mind” type justifications of Daniel’s behavior does not indicate that these children do not understand the mind. But, perhaps understanding the mental states of others is not the same as understanding another’s reasoning on cognitive tasks. As described, the understanding of the mind as active is something that develops during the early school years (e.g., Flavell et al., 1993). The question remains whether children understand thinking about problem-solving tasks as an active type of mental processing. Do children understand such reasoning as the gravity error as a belief that is false or as a faulty processing that children engage in on each trial? As current research stands, it seems difficult to draw firm conclusions about this.

If children’s post-hoc descriptions of the gravity misconception and their talk about the mind do not predict children’s performance, what does? What can account for children’s seeming inability to use past evidence about performance on a cognitive task to attribute thoughts to another person? Researchers have proposed that differences in such facets as social-emotional maturity (Lalonde & Chandler, 1995) and family structure (Jenkins & Astington, 1996; Perner, Ruffman, & Leekam, 1994) may account for differences in theory of mind development. Yet, these factors seem distant from the task at hand.

Perhaps the best approach to answering such questions is to ask further questions. What further skills are required to coordinate one’s representation of a task with another person’s different representation? How well do children use past evidence to learn about other’s cognitive abilities? Is this a skill that they use in classrooms? Or do children focus largely on their own cognitive achievements rather than the cognitive misconceptions of others? This study certainly provides a catalyst for further examination of such issues.

Overall, the results of the present study do suggest that theory of mind development is not complete by the age of 5. The ability for children to recognize and articulate the misconceptions or errors that other children have about particular cognitive tasks is certainly not mature by age 8. Furthermore, this ability may be task or even domain specific. A general knowledge of how the mind works may not be sufficient for interacting with others in situations which involve cognitive tasks.

CONCLUSIONS

Theory of mind work has enlightened what we know about young children's cognitive development. A variety of studies have shown that young children have a rudimentary understanding of the mind and how it operates. Yet, this work has remained limited with respect to how it informs us about children's use of theory of mind in social situations. Thus, the nature of our understanding of theory of mind must make a radical shift.

First, further demonstrations of children's understanding of the mind as active and interpretive are logical steps in explaining their development to a more adult-level of cognition. This more mature appreciation for the complexity of cognition may be the key to understanding changes in children's ability to take others' perspectives (Chandler & Lalonde, 1996). Such an ability seems inherently necessary for successful collaborations and social interactions between children (Tomasello, et al., 1993; Wood, Wood, Ainsworth, & O'Malley, 1995) just as knowledge of emotions helps our understanding of social interactions (Gnepp & Chilamkurti, 1988). If children can (1) recognize diversity in thought, (2) the active nature of the mind, and (3) the possible cognitive misconceptions of others, they may be better able to apply their theories of the mind to social situations. Theory of mind, in this sense, is important in the interactions children engage in during which they need to consider another's reasoning.

In light of the present findings, several avenues for future research can be explicated. Certainly, more studies of older children's theory of mind must be conducted. However, a different approach needs to be developed. Videotapes of other children as well as real interactions with others may provide better contexts for examining what older children know about others' thinking.

In addition, a closer examination of children's verbal descriptions of others' thoughts is needed. If children can articulate what they perceive another person's thoughts to be, it may inform researchers about their level of understanding the mind. Researchers must reconsider how much knowledge of the mind can be attributed to children simply based on their predictions of others' behavior.

Moreover, the knowledge that children have about different domains of knowledge (e.g., memory, math, science) may be a logical starting point for examining the reasoning of others. Understanding that others have beliefs has been repeatedly attributed to young children. Little consideration has been paid to the various domains in which people hold beliefs. A considerable breadth of work has been done in the area of metacognition, an area that has provided plausible accounts of older children's knowledge of cognitive processes (Baker, 1994; Flavell, 1979). Yet, the gap between this older literature and the recent theory of mind studies has not been adequately bridged. While much is known about children's understanding of domains such as memory, few studies have directly examined what they understand about other people's beliefs and thoughts within these domains.

Given such plausible directions for studies, theory of mind work could be drawn closer to the work that it claims to be most important – how we interact with others. Children could use cues from the child's body language, or even eye gaze, to infer the child's knowledge or confusion about the task (Flavell, Green, & Flavell, 1990; Lee, Eskritt, Symons, & Muir, 1998). In the present study, children were given the opportunity to play the role of the observer rather than collaborator. However, when children are actually collaborating with another person, their understanding of the person's reasoning may be entirely different. In a true social interaction, they could ask the person directly about his or her responses or even provide help when the person makes errors. Such behavior might be better indices of what they understand about another's behavior as distinct from their own correct reasoning. A different picture of

children's understanding of another's reasoning may emerge if we examine more closely what occurs within social interactions. (Fuller discussions of the nature of learning within social interactions can be found in Tomasello et al., 1993.) Gaps between literature on social development, peer tutoring, peer collaboration, and instructional settings may be filled by furthering our understanding of the cognitive strengths and weaknesses children bring to such situations.

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BIOGRAPHICAL SKETCH

Jennifer Lyn Slawinski was born in Staten Island, New York on August 5, 1970. She grew up on Long Island and graduated from Smithtown High School West in 1988. In search of fairer weather, she moved to North Carolina and received her B.A. in psychology from Wake Forest University in May 1992. Her participation in the undergraduate honors program in psychology fueled in her a desire to do research. She remained at Wake Forest and continued her work on children's memory development with Dr. Deborah Best. She was awarded her M.A. in psychology from Wake Forest University in May 1994; her thesis examined children's predictions of their own memory abilities. Without a consideration for humidity, she moved to Gainesville and began her PhD studies in developmental psychology at UF in the fall of 1994. Now, with her degree "phinally" in hand, she's continuing to battle Gainesville's humidity for the next year with a job teaching at UF as an adjunct assistant professor. Meanwhile, she will be on the job market for a tenure-track position as an assistant professor – perhaps in a milder climate.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Shari Ellis, Chair
Assistant Professor of Psychology

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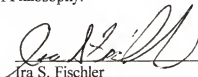
Patricia H. Miller, Cochair
Professor of Psychology

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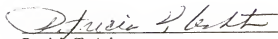
Scott A. Miller
Professor of Psychology

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Ira S. Fischler
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Patricia T. Ashton
Professor of Foundations of Education

This dissertation was submitted to the Graduate Faculty of the Department of Psychology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Dean, Graduate School